Coronal Jets from Minifilament Eruptions in Active Regions

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Abstract

Solar coronal jets are transient (frequently of lifetime ~10 min) features that shoot out from near the solar surface, become much longer than their width, and occur in all solar regions, including coronal holes, quiet Sun, and active regions (e.g., Shimojo et al. 1996, Cirtain et al. 2007). Sterling et al. (2015) and other studies found that in coronal holes and in quiet Sun the jets result when small-scale filaments, called ``minifilaments,'' erupt onto nearby open or high-reaching field lines. Additional studies found that coronal-jet-onset locations (and hence presumably the minifilament-eruption-onset locations) coincided with locations of magnetic-flux cancelation. For active region (AR) jets however the situation is less clear. Sterling et al. (2016) studied jets in one active region over a 24-hour period; they found that some AR jets indeed resulted from minifilament eruptions, usually originating from locations of episodes of magnetic-flux cancelation. In some cases however they could not determine whether flux was emerging or canceling at the polarity inversion line from which the minifilament erupted, and for other jets of that region minifilaments were not conclusively apparent prior to jet occurrence. Here we further study AR jets, by observing them in a single AR over a one-week period, using X-ray images from Hinode/XRT and EUV/UV images from SDO/AIA, and line-of-sight magnetograms and white-light intensity-grams from SDO/HMI. We initially identified 13 prominent jets in the XRT data, and examined corresponding AIA and HMI data. For at least several of the jets, our findings are consistent with the jets resulting from minifilament eruptions, and originating from sites of magnetic-field cancelation.

Introduction

- Active region NOAA AR 12259 was followed for a week by Hinode from 2015/01/13 14:34:16 to 2015/01/20 06:30:36.
- We examined the XRT movie of this active region, and identified 13 strong XRT jets. Table 1 (bellow) lists the 13 jets.
- We looked at all AIA wavelengths for each of the jets. We also looked at HMI data for the jets that were not too close to the limb starting from our earliest event on 2015/01/13 15:56:01 to 2015/01/18 when we start to approach the solar limb.
- We inspected movies of the images for each of the jets. We also looked at the magnetic environment of each jet.
- We also looked for evolutionary changes of the magnetic field at each jetting location.
- In the following we will display results of three jets in detail. We will then summarize the findings for the rest of the jets.

Events	Start Time of Eruption
Event 1	2015/01/13 17:35:37
Event 2	2015/01/13 15:56:01
Event 3	2015/01/13 17:15:13
Event 4	2015/01/14 09:22:13
Event 5	2015/01/14 14:13:01
Event 6	2015/01/14 15:57:49
Event 7	2015/01/14 17:35:49
Event 8	2015/01/15 08:37:01
Event 9	2015/01/15 22:24:37
Event 10	2015/01/16 16:27:13
Event 11	2015/01/17 00:04:01
Event 12	2015/01/18 16:28:13
Event 13	2015/01/19 12:18:01

Table 1: Eruption onset time for each event from the XRT movie.

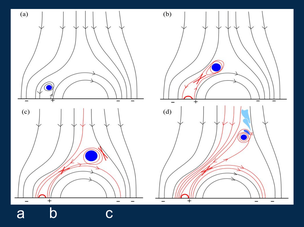


Figure 1: Schematic of minifilament erupting to form a jet, and a "jet bright point" (JBP). (Sterling et al. 2016.) Magnetic locations indicated by "a," "b," and "c" of panel (c) relates to arrows in Figure 2(a).

Results

- We illustrate our results with images of 3 of our 13 jets. Figure 2 shows evolution of event 4 of Table 1. The top row shows the evolution from the start of the jet until its maximum extent, in AIA 193 A images. From the magentogram in Figure 2(e), we see that the eruption starts at the magnetic neutral line between arrows a and b in Figure 2(e). From movies of the 193 images, we can observe cool material - a minifilament - erupting from this neutral line. This is in agreement with the schematic of Figure 1(c) (which shows the Figure 2(e) magnetic polarities labeled as 'a', 'b', and 'c'). Figures 2(g) and 2(h) show the jet after the western (right) end of its base brightening has spread to the negative polarity at arrow c in Figure 2(e).
- Figure 3 is event 1 of Table 1. It is homologous with the jet of Figure 2, occurring at nearly the same location after originating at the same (slightly modified) neutral line.
- Figure 4 shows event 13 of Table 1. It occurred at a different location from the jets of Figures 2 and 3. It shows a clear minifilament (arrow) ejecting out of a location that brightens as the jet bright point.
- In the magnetogram images, red and green represent positive and negative polarities, respectively. From several-day-long movies of the magnetograms, we could see that magnetic cancelation occurred at the neutral line from which the jets of Figures 2 and 3 originated. Similarly we found cancelation to be occurring at the sights of origin of most jets (with only one case being questionable).

Figure 2 2015/01/14

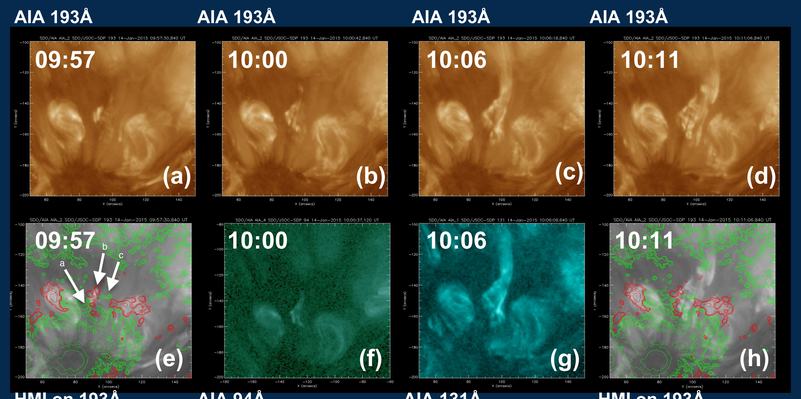


Figure 3 AIA 131Å 2015/01/13

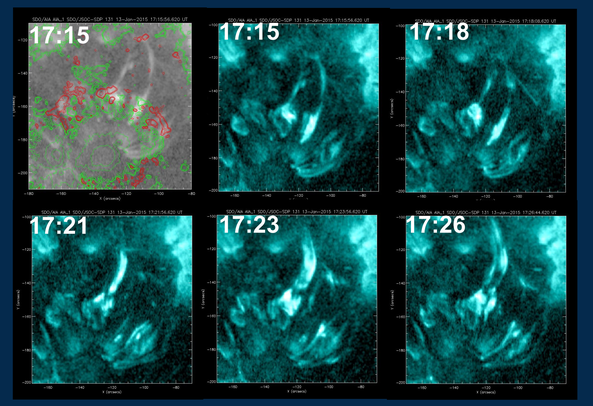
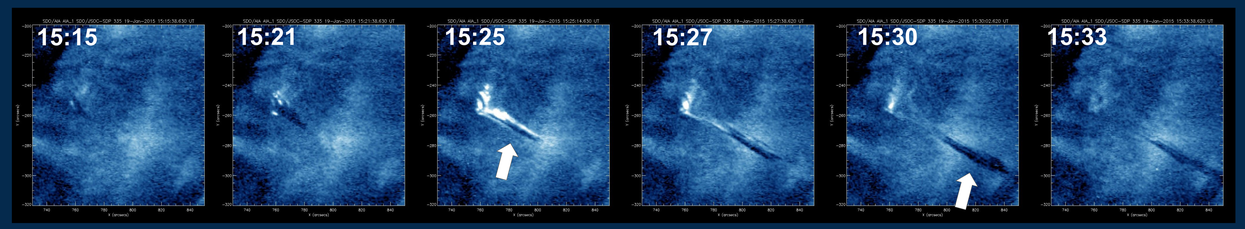


Figure 4 AIA 335Å 2015/01/19



Conclusion

We found that at least 10 of the 13 events showed strong evidence for the source of the jet to be eruption of a minifilament. For one event (event 10) it is unclear whether a minifilament eruption was the source of the jet, while in two of the cases (events 11 and 12) further investigation is still required to make a determination. The minifilaments can be subtle to detect, both because they can be small scale (width of a few arcseconds), and they sometimes can quickly become engulfed in surrounding bright material that can obscure the cooler material from an early phase. All of the jets occurred near magnetic neutral lines, and for all but one case we found flux cancelation to be occurring at these neutral lines (the situation for event 10 is uncertain). Our findings that at least many active region jets result from minifilament eruptions is consistent with the findings of Sterling et al. (2015) that polar coronal holes jets result from minifilament eruptions. Similarly, jet occurrence at sites of flux cancelation is consistent with other studies of on-disk jets (e.g., Hong et al . 2011, Huang et al. 2012, Adams et al. 2014, Young & Muglach 2014).

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